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This Master's Project

**RISKY BUSINESS:
RECOMMENDATIONS FOR THE INSURANCE INDUSTRY TO CONTRIBUTE TO
GREATER DISASTER RISK REDUCTION AND CLIMATE CHANGE ADAPTATION**

by

Jessie Goodwin Rountree

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Abstract

The private insurance industry is susceptible to increasing risk from climate change and can serve as a catalyst to change behavior to minimize loss. The research examined the current impact and future potential of the insurance industry to reduce both physical and financial risk. The insurance industry currently raises awareness, assigns an economic value to risk, advocates for climate change action, and takes measures to reduce physical risk through mitigation. As well, the industry has proven to be a critical influencer to encourage risk-adverse behavior and regulation. Recommendations to the industry to have a greater impact include: 1) pursue more private/public partnerships, 2) make risk-prediction models more accurate and more accessible, 3) expand investments in green bonds and similar impact investments, and 4) increase disaster risk reduction services. These recommendations emphasize the importance of collaboration with non-profits organizations, governments, the scientific community, and industry peers. Private and public entities should continue to partner with and encourage the industry to pursue innovative solutions to reduce the financial and physical risks related to climate change.

Keywords: insurance industry, climate change, mitigation

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INTRODUCTION

Recent weather disasters have highlighted the potential of the natural environment to impact society and the economy. This is especially true in North America, where 74% of total global economic losses from weather-related events occurred in 2012 (Swiss Re, 2013a). Damages from Hurricane Sandy in 2012 alone resulted in an estimated 147 direct deaths and over 50 billion USD in losses (U.S. Department of Commerce, 2013). The Intergovernmental Panel on Climate Change (2013) predicts future weather events to occur at similar or greater frequency and magnitude as the effects of climate change, primarily increasing sea temperature, continue. Simultaneously, increasing global economic development is likely to put more people and greater value in the path of such destructive weather, resulting in greater potential devastation.

The effort to reduce such losses and ensure societies are better prepared needs to match the scale of potential damage. This will require input and collaboration from the government, non-profits, and private sectors. One private industry is especially susceptible to increasing risk from climate change and can serve as a catalyst to change behavior to reduce risk—the insurance industry.

The insurance industry is in the business of sharing financial risk to reduce the impact of devastation from hazards, and potentially has much to lose given increasing risks from climate change. The insurance industry currently is responsible for approximately 40% of catastrophe economic losses in industrialized countries (Hoeppe and Gurenko, 2006). The private insurance market takes on trillions of dollars of insurance risk annually (Geneva Association, 2013a). The industry is regarded as “an important part of society's climate observing system, integrators of the costs of weather-related hazards, and messengers of the implications through their pricing and terms. It also can be an agent of preparedness and recovery, essentially a component of society's adaptive capacity” (Mills, 2009).

The role of the insurance industry in disaster risk sharing and reduction is gaining recognition because of recent major disasters (Swiss Re, 2013c). Such visibility represents an opportunity for the industry to raise awareness of risk and possibly influence the behavior of policyholders and other society members to reduce risk. Such reductions may benefit society, but are ultimately motivated by business decisions to maximize profit. Climate risks impact nearly

all lines of insurance and as such, reducing risk through mitigation behavior can make losses more manageable (Mills, 2007). In the case of the insurance industry, what is good for the bottom line can also be good for the environment and society.

The insurance industry already increases awareness of risk and incentivizes mitigation and adaptation through policy pricing. The purpose of this research is to explore ways for the industry to influence greater change. Chapter 1 introduces environmental risk and explores what factors influence behaviors to mitigate risk. Chapter 2 provides an in depth overview of the insurance industry, including its history, business practices, and varying products. Chapter 3 highlights how the industry increases awareness of risk and assigns a monetary price through premiums. Chapter 4 highlights how the industry already reduces physical risk by incentivizing mitigation and adaptation behavior as well as advocacy. Chapter 5 provides recommendations to the industry to further reduce physical risk, followed by challenges to these opportunities in Chapter 6.

CHAPTER 1: ENVIRONMENTAL RISK

Climate change is regarded as a significant source of risk and opportunity facing the private and public sectors. It is anticipated to “influence all aspects of industry, including internal operations and infrastructure, client engagement, product development and innovation, investment analysis and modeling, and credit policies” (Brimble, Stewart, & de Zwaan, 2010, p. 72). The economic and social costs of severe weather events have influenced business to acknowledge and adequately prepare for more frequent and significant loss from environmental risks.

Environmental risk is defined as the potential for adverse financial impacts arising from environmental losses (Rogers, 2005). The degree of risk varies based on the probability of an event occurring times its consequences or impact (Dobler, Lajili, & Zéghal, 2012). The International Council of Scientific Union’s Scientific Committee on Problems of the Environment (1980) identified seven characteristics that are unique to environmental risk and are important to consider for management efforts; they state that environmental risks:

1. Involve a complex series of cause and effect relationships;
2. Are connected to each other—so several or many risks occur simultaneously within the same country, region, or city;
3. Are connected to social benefits so that a reduction in one risk usually means a decline in the social benefits derived from accepting the risk;
4. Are widespread over the globe and concern many countries, both developed and developing;
5. Are not always easy to identify;
6. Can never be measured precisely; and
7. Are evaluated differently in social terms—so the severity of risk may differ based on the person or society that is experiencing it. (The International Council of Scientific Union, Scientific Committee on Problems of the Environment, 1980)

Environmental risk can be further broken down into five types—regulatory, physical, competitive, legal, and reputational (Ceres, 2010). Table 1 describes these types of risk. Physical

risk is conceptually different from other forms of risk and includes the impact of nature beyond a party's control. Physical risk encompasses climate change, seasonality, natural disasters, and weather conditions (Dobler et al., 2012). Physical risk arising from environmental losses is the focus of this research.

Table 1

Types of environmental risk and descriptions

Type of risk	Description of risk
Regulatory	New regulation on pollution limits or greenhouse gas emissions may pose new costs and compliance obligations to some companies.
Competitive	A new set of regulatory expectations and/or a changing physical environment could lead to a new competitive environment, through increased fuel costs or an increase in competition for dwindling resources, such as water, leading to other increased costs.
Legal	Potential losses from litigation, especially from those seeking damages from alleged contributors to climate change.
Reputational	Companies may face reputational losses if they are associated with climate-related damages or perceived mismanagement of the climate change risk environment.
Physical	Physical damage from natural catastrophes like hurricanes, floods, and winter storms.

Note: Excerpt from “Climate Change Risk Perception and Management: A Survey of Risk Managers,” by Ceres, 2010.

The importance of predicting physical risk

Destructive weather has proven that the economic wellbeing of any institution, be it governmental or a private company, is in some way influenced by the changes that occur in the environment. Kenneth Abraham, a scholar and teacher in the field of insurance law, predicted this influence in his book *Distributing Risk* (1986). Abraham hypothesized that “if one can predict changes in the environment, one may reasonably predict the broad outlines of the change that may occur within the institution concerned” (1986, p. 1).

Companies are increasingly aware of the potential impact of environmental risk and their reliance on natural resources in their supply chain (The United Nations Office for Disaster Risk Reduction, 2013). A survey of corporate risk managers conducted by Zurich, a private insurance company; the Professional Risk Managers' International Association; and Ceres, a non-profit

organization advocating for sustainability leadership, assessed whether and to what extent risk managers are worried about the risks from climate change, including physical and regulatory risk. The resulting report analysis revealed concern about nearer-term physical risk from climate change was stronger than expected. The physical damage from catastrophic weather events are heavily publicized, but disasters can also impact supply chains and business operations. Respondents of the survey expressed concern that physical effects could “affect business by compromising their physical assets, disrupting supply chains or raising the costs of commodities such as water” (Ceres, 2010, p. 21).

Companies and governments alike strive to predict such changes in the environment and pursue environmental preparedness strategies to avoid or reduce the impact of losses. The United Nations Office for Disaster Risk Reduction (2013) acknowledges that risk management in business processes is increasingly seen as a key to resilience, competitiveness, and sustainability. Savings from effective risk management may even fund other corporate activities (The United Nations Office for Disaster Risk Reduction, 2013). Such proactive environmental management is necessary to minimize losses and increase future cost savings, and has lead to several innovative and non-traditional collaborations.

For the last six years, Cola-Cola has partnered with the World Wildlife Fund to “help conserve and protect the world’s freshwater, as well as to address the challenges that affect water, including climate change and unsustainable agriculture” (World Wildlife Fund & The Coca-Cola Company, 2013, p. 1). Cola-Cola’s primary ingredient in their products is water. By protecting freshwater supply quantity and quality, the company can reduce risk and ensure continued sale of their products. Similarly, Wal-Mart was concerned about being unable to meet consumer demand due to expected reductions in fish stocks globally caused by unsustainable fishing (Plambeck & Denend, 2011). Wal-Mart partnered with the Marine Stewardship Council, who maintains a sustainable fish certification program, to adjust their supply chain to only purchase fish that are sustainably produced. This successful partnership aims to improve fish stocks globally, advancing the goals of the Marine Stewardship Council and simultaneously reducing risk to Wal-Mart’s profits.

These examples illustrate the potential of environmental risk to motivate action, including innovative solutions through non-traditional partnerships. The type and degree of environmental risk and opportunities from climate change may vary by industry, but having a diversified view

of a company's environmental exposure is regarded universally as a wise business decision (Semenova & Hassel, 2008).

Disconnect between risk awareness and mitigation action

Though risk awareness and preparedness are regarded as positive business practice, they do not always lead to preventative actions. Inaction may be attributed to several factors including how the risk is assessed and also how it is perceived. Risk can be broken down into “objective risk”—the variance of a probability distribution of loss-causing events—and “subjective risk”—the attitude experienced by the individual facing risk (Greene, 1971, p. 7).

Objective risk

One reason for an inadequate mitigation response may be incorrect information, or inaccurate objective risk. The magnitude of environmental risk is estimated through complex modeling that is both expensive and time-intensive. Not all governments or companies have sufficient resources to commit to proper modeling and analysis, which can result in incorrect or conflicting estimates of environmental risk and inappropriate risk mitigation efforts. For example, a company that underestimates risk is likely to be inadequately prepared, leading to greater losses. Alternatively, a company that overestimates risk may tie up more valuable capital than necessary to protect against less significant losses. Either experience may change a company's perception of the benefits of preparedness.

Subjective risk

In addition to reliability of risk information, an individual or institution's attitude plays a significant role in whether or not they take appropriate action. This was observed specific to flood risk perceptions and the relationship to mitigation behavior in the Europe (Bubeck, Botzen, & Aerts, 2012). Shifting European policies to successfully alleviate flood risks required private household to take more flood mitigation measures. Understanding the relationship between risk awareness and mitigation action was important to predict the success of the overall policy to reduce flood damage.

Bubeck et al. (2012) hypothesized a positive relationship between awareness of risk and mitigation behavior. However, they found that such a relationship was hardly observed in empirical studies, and concluded that high-risk perception does not necessarily result in improved mitigation behavior. This was in part attributed to the “protection motivation theory,” a psychological model used to explain decision-making in relation to threats (Figure 1). The model identifies two appraisal states, “threat appraisal” and “coping appraisal.” Threat appraisal is also referred to as a risk perception, or how an individual evaluates how threatened they feel in response to a certain risk. After an individual feels threatened, they begin to transition to coping appraisal, which involves thinking about benefits of possible actions and evaluation of competencies to carry them out.

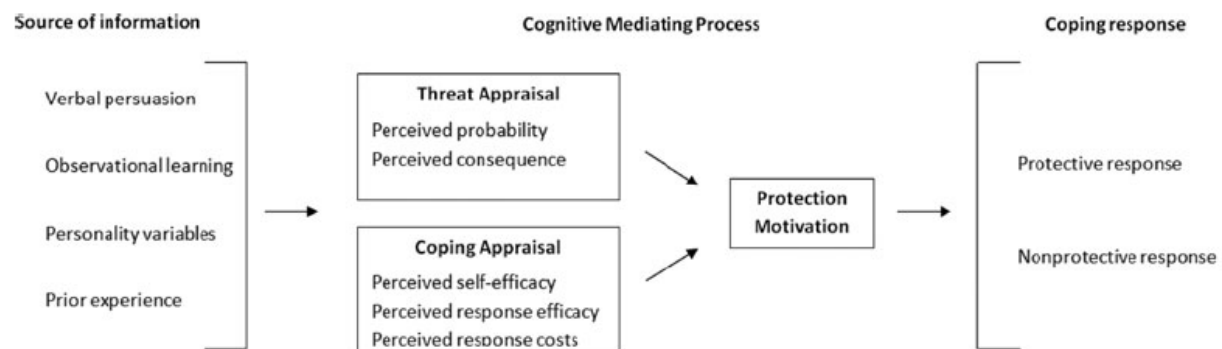


Figure 1: Schematic overview of protection motivation theory. Excerpt from “Protection motivation and self-efficacy: A revised theory of fear appeals and attitude change,” by J.E. Maddux and R.W. Rogers, 1983, *Journal Of Experimental Social Psychology*.

In a study evaluating health-related protective behavior by Maddux and Rogers (1983), coping appraisal was found to be a greater predictor of action than the threat appraisal component. Within coping appraisal, perceived self-efficacy, or a person’s perception of whether or not they are capable of performing a requisite behavior was a key component (Maddux & Rogers, 1983).

Overall, it is the combination of threat awareness and the benefit of solutions that determines action. Bubeck et al. (2012) acknowledge this and recommend that risk

communications be accompanied by additional information on the effectiveness of flood measures and guidance on how to implement them. Looking beyond the protection motivation theory, the authors found that perceptual factors (including “perceived effectiveness of measures, their estimated costs, and the perceived responsibilities in flood management”) were better predictors of precautionary behavior than socioeconomic and geographic factors (p. 1493).

Who originates risk awareness and why?

The protection motivation theory and perceptual factors are important to understand what motivates mitigation behavior once an individual or institution understands the risk. However, the theory does not identify who is likely to originate risk awareness in the first place. Table 2 identifies four different public and private parties that are likely to originate risk awareness and possible motives for taking mitigation action. All parties contribute to cumulative risk awareness and should be considered as part of a broader solution to encourage more mitigation to reduce risk.

Table 2

Parties that contribute to risk awareness and their motivations

Party	Motive for Action
Governments	Ultimately responsible for protection of society through emergency relief and government infrastructure
Non-profits & international aid	Commitment to well-being of the population exposed to risks
Individual companies	Greater understanding of risk may motivate changes to operations to reduce exposure and minimize potential loss
Private insurance industry	Greater understanding of risk to create business opportunity to maximize profit and minimize loss

Within the private sector, the insurance industry is well-positioned to further awareness of climate change and advance mitigation and adaptation solutions (Mills, 2009). Unlike some other industries, the insurance industry sees action on climate change as being less costly than inaction. The industry integrates the cost of weather related hazards through models and serves

as messengers of implications through policy pricing and terms (Mills, 2009). The geographic and financial scale of the industry, the largest in the world, also has the potential to educate and influence policyholders broadly (Mills, 2009).

The insurance industry accumulates more risk than other private industries. Risks are transferred from individuals and companies to primary insurers through insurance policies. Primary insurance companies assume the risk of the insured based on terms in a contract for a fee, the premium. The insurance industry is a powerful driver of the global economy; every sector of the economy depends on insurance and, similarly, insurers are exposed to risk in every sector of the economy (Leurig & Dlugolecki, 2013). Insurance companies often purchase separate coverage to reduce the losses they may incur as a result of the contracts with policyholders. This additional “insurance for insurance companies” is known as reinsurance (MarketLine, 2013). The full transfer of risks is then from individuals and companies, through primary insurers, to the reinsurer (Swiss Re, 2013c). The reinsurance sector assumes the risk of other insurance policy holders from various sectors globally including, but not limited to, energy, chemical production, and agriculture.

An analogy for the accumulation of risk by the insurance and reinsurance sectors is the accumulation of mercury in a food chain. Plankton exposed to mercury is eaten in large quantities by smaller fish, so the mercury concentration in the small fish is higher than that of the individual plankton. A larger fish eats the smaller fish, and the chain continues, ending with the apex predator—the tuna. The tuna, having consumed the other species, also accumulates their mercury and is left with a potentially harmful level. This is comparable to the risk transfer of a policyholder to ultimately a reinsurance company. For example, risk of wind damage is transferred from the homeowner to the primary insurer through a policy. The homeowner pays the insurance company a premium to protect themselves from a greater magnitude of risk. The primary insurer covers multiple policies from homeowners and consolidates their risk. A primary insurer may enter into a separate contract with a reinsurer to reduce their level of consolidated risk. The insurer similarly pays a premium to the reinsurer to protect themselves from risk of damages. Should a severe hurricane occur and cause damage from wind, multiple homeowners will file claims to their primary insurers to cover the cost of damages. Depending on the terms of the contract with the reinsured, the primary insurer will then pay a portion of the refunds to the homeowners and file a claim to the reinsurance company. Similar to the affect of

mercury to the tuna, too much risk can be negative to the reinsurer and may result in decreased profit.

As the magnitude of environmental risk increases globally with climate change, so does the risk increase to the insurance and reinsurance sectors. Due to this concentration of risk, both insurance and reinsurance companies within the industry have an incentive to understand and possibly reduce environmental risk.

CHAPTER 2: FINANCIAL RISK TRANSFER: OVERVIEW OF THE INSURANCE AND REINSURANCE SECTORS

The insurance industry shares risk by shifting financial consequences from one party to another. This chapter provides an overview of the industry, including both the insurance and reinsurance sectors, to introduce different parties and mechanisms to transfer risk. A greater emphasis is placed on reinsurance because it is a critical component of transferring risk globally but generally less familiar to the public. The chapter concludes with non-traditional insurance and reinsurance products that are also used to share risk.

Traditional primary insurance

Primary insurance provides coverage that transfers financial risk from the insured to the insurer. Several key terms are helpful to define:

- An **insured** is a person, business, or organization that is covered by an insurance policy.
- A **loss** is a decrease in net assets for which no revenue is obtained.
- **Risk** is the uncertainty of loss, chance of loss, or the variance of actual loss from expected results as it relates to coverage. The risk is unique to the object of insurance protection (e.g., a building, an automobile, a human life, or exposure to liability).
- An **insurance company**, also known as the **insurer**, sells insurance policies that protect the insured against financial hardship caused by financial losses. Insurers accept the risk of the insured, collect premiums, and pay losses.
- **Insurance premium** is a periodic payment to the insurer in exchange for insurance coverage. Included in payment are also the administrative fees of the insurer to create and manage the policy. (Reinsurance Association of America, 2007)

Combining these terms, insurance is “a system by which a risk is transferred by a person, business, or organization to an insurance company, which reimburses the insured for covered losses and provides for sharing the costs of losses among the insured” (Smith & Wining, 1994, p. 3). This transfer of risk is finalized through a contract, or insurance policy, that states the rights and duties of the insurer and the insured. The primary duty of contracts is to confirm the responsibility of the insurance company to indemnify the policyholder.

The contract also confirms the insurance deductible, the amount of loss borne by the insured and the premium price. The deductible is the amount the insured has to pay out-of-pocket for expenses before the insurance company will cover any remaining costs. Higher deductibles generally result in lower premiums because the insurer is responsible for less loss. The premium price is determined in part by the possibility of risk; when a loss is almost certain, insurance companies charge a premium as high as the expected loss. The insurer uses the premium to pay claims for occurred loss in excess of the deductible, pay expenses including the cost of operation for the insurer, and generate profits (Smith & Wiening, 1994). It is important that the premium be high enough to adequately cover payout of future losses, but low enough to not be excessive. As discussed in Chapter 4, premium pricing can incentivize loss control, including proactive efforts to mitigate risk, by rewarding the insured with lower premium rates. Conversely, higher premium prices may be a disincentive for more risky behavior, including development in catastrophe prone area.

Profit

The insurance sector generates profits by paying out less than what it receives in premiums and investing the net amount, or reserve. The interest on the investments is subject to corporate income taxes. If a company incorrectly assesses the risk or prices a premium too low, it may have to pay out to policyholders more money than what it received in premiums. With smaller or no reserves, the company makes fewer or no investments—something that hurts both the company's profit and possibly also the broader economy. The investment activity of the insurance sector is in fact very significant. American insurers are one of the world's largest investors, controlling nearly 5 trillion USD in invested capital (Insurance Information Institute, n.d.; Leurig & Dlugolecki, 2013). The insurance sector also provides financial support to policyholders when disasters occur. This can allow a rapid return to pre-disaster business and social activity, which can drastically impact the broader economy.

Government regulation and insurance

Federal and state governments acknowledge the impact of the insurance sector on the wellbeing of policyholders and the larger economy. They regulate reserve amounts, impact

private premium prices, and serve as public insurers. Governments require that insurance companies have adequate reserves on hand that are large enough to pay back all the unearned premium on all of their policies (Smith, 1964). The benefit of this reserve requirement is that policyholders will receive a full payout when needed. However, the need to maintain these reserves reduces the amount of policies that an insurance company can take on as well as the amount that they can invest. This may ultimately result in less profit to the company and less available coverage to society.

Governments also regulate private insurance rates as a means to keep risk coverage rates low and affordable to residents. Some states in the United States regulate current premium prices as well as any proposed rate changes from private insurance companies to ensure coverage remains affordable (Smith & Wienen, 1994). Though these regulations are in place to provide aid to society, they may indirectly encourage risky behavior by pricing premiums too low (Israel, 2013).

In addition to regulating the reserve and private premium prices, some governments also serve as the insurance provider (Kousky, 2011). Many natural hazards are insured through private insurance companies, but some insurance (like flood and crop insurance), are managed through government programs (Mills, 2005). Federal and state insurance programs offer insurance to residents who cannot obtain policies in the voluntary or private market (Kousky, 2011). Federal programs are designed to protect the population against risks from disasters that were historically deemed uninsurable by the private market because of their scale of impact (Mills & Lecomte, 2006). The National Flood Insurance Program (NFIP), for instance, provides flood insurance to property owners in flood zones including many coastal areas.

Most state catastrophe programs were established after an extreme event that depleted reserves of private insurers and reinsurers. As a result of depleted reserves, insurance companies increased premium prices, reduced coverage, limited the number of policies, or withdrew from the high-risk locations altogether (Kousky, 2011). Governments stepped in to offer coverage and regulate rates. In Florida, insurance is provided directly to consumers through the Citizens Property Insurance Corporation. To make public insurance more affordable, premiums are often priced below the true cost of risk and subsidized. As an example, Citizens subsidizes those in the highest-risk areas by charging more of policyholders throughout the state (Kousky, 2011).

The importance of risk based premium pricing

Risk based premium pricing is essential for a provider to be solvent. Government programs that price premiums below the cost of risk can result in program debt. Federal and state insurance programs have had varying degrees of success (Table 3). NFIP was bankrupted 10-times over by Hurricane Katrina and as of February 2014, was 24 billion USD in debt (Koba, 2014; Mills & Lecomte, 2006). The California Earthquake Authority (CEA) is an example of a successful state program. The CEA's success is attributed to risk based premium pricing that is not subsidized. For the private insurance sector, not using risk based premium pricing results in less profit. The impact of premiums to influence behavior to reduce physical risk is described in Chapters 3 and 4.

Table 3

Selected legislative and policy responses to highlight initiatives that have had varying degrees of success in advancing risk mitigation and providing appropriate insurance coverage

Insurance	Type of Program	Status (as of 2011)	Issues
Citizens' Property Insurance Corporation/ Florida Hurricane Catastrophe Fund (Florida)	Government-run property and casualty insurance pool and reinsurance fund for wind and hurricane.	Citizens' issues almost 1.3 million policies (18% of admitted Florida market) 18 Citizens' 11 billion USD shortfall in 100-year event would be covered by assessments.	Reliance on post-loss funding.
National Flood Insurance Program (US)	Government flood insurance program authorized by statute. Original intent was to decrease reliance on ad hoc post disaster relief by offering insurance to those most at risk.	More than 5.6 million properties insured; current 17.8 billion USD deficit.	Risk mitigation measures required by the program are not always implemented or enforced; flood maps are out of date; limited ability of the program to adjust premiums or coverage to reflect risk.
California Earthquake Authority (CEA)	Publicly managed, privately funded residential earthquake insurance provider.	CEA is solvent; however, only approximately 12% of market is covered.	Fiscally solvent; risk based premium pricing; State does not subsidize CEA and vice-versa; inadequate uptake because of cost of premiums, resulting in part from high mandated reinsurance costs and from large risks of properties without retrofits.

Note: Excerpt from "Managing the escalating risks of natural catastrophes in the United States," by Lloyds, 2011.

Traditional reinsurance

Traditional reinsurance can help both private and government insurers reduce potential losses by transferring financial risk. The success of the reinsurance sector requires that risk be fully recognized and priced accordingly, especially given the increasing magnitude of risk from climate change.

Reinsurance is commonly described as insurance for insurance companies. Though this oversimplification does exclude critical details of the sector, it does capture the basic business, which includes “a financial transaction by which an insurance company is indemnified for all or a portion of some risk by another insurer” (Abramovsky, 2008). Through this transaction, risks are transferred from individuals and companies, through primary insurers, to the reinsurer (Swiss Re, 2013c). Self-insured parties also purchase reinsurance. Self-insured parties are those that set aside money to compensate for the potential future loss themselves rather than taking out a primary insurance policy.

The insurance company purchasing reinsurance is known as the ceding insurer. The company selling reinsurance is known as the reinsurer. Reinsurance reduces financial risk to the ceding insurer because it provides reimbursement for losses covered by the reinsurance agreement (American Management Association, 1964). This allows the ceding insurer to offer primary insurance coverage for unpredictable events and still limit their exposure when large losses occur.

Perhaps equally important to understanding the role of reinsurance is to understand what reinsurance is not. Though reinsurance can transfer financial risk and provide liquidity to reduce indirect damage, it does not alter the total risk exposure (Reinsurance Association of America, 2007; Warner et al., 2009). Though modeling helps to better understand risks to price premiums and policies accordingly, reinsurance “does not make exposure more predictable or desirable” (Reinsurance Association of America, 2007, p. 6). Reinsurance and insurance companies can incentivize risk management techniques and mitigation behavior as a means to reduce risk, a concept described in Chapter 4. Though some reinsurers also offer risk preparedness as a separate service in order to proactively reduce risk at the operating or local level, this is not a standard component of reinsurance to transfer risk.

Motivation for buying reinsurance

The motive for an insurance company or self-insured party to purchase reinsurance is the same motive that prompts individuals and businesses to purchase primary insurance—“to reduce uncertainty by transferring some risks and sharing losses” (Smith & Wiening, 1994, p. 41). This coverage may seem redundant and perhaps unnecessary, but it is critical to limit liability of a primary insurance company. Insurers purchase reinsurance for four main reasons: 1) limit liability, 2) provide stabilization, 3) increase capacity, and 4) provide catastrophe protection (Reinsurance Association of America, 2007) (Table 4). Because of reinsurance, primary insurance companies can offer policyholders adequate coverage, keep prices of policies affordable, and reduce operating costs globally.

Table 4

Motives to purchase reinsurance

Limit liability	Reinsurance provides a mechanism through which insurers limit their loss exposure by transferring risk from the reinsured to the reinsurer. The reinsurer is then required to maintain adequate reserves to pay back unearned premium on all of its policies and not the reinsured (Abramovsky, 2008). This enables them to take on additional policyholders or invest a portion of their reserve. This also benefits the primary policyholder because the primary insurer can offer higher coverage limits.
Stabilization	Insurers, as well as reinsurers, experience fluctuations in profit and loss margins in part because the work includes pricing a product (or coverage) whose actual cost will not be known until a future time. Insurers can stabilize their overall operating results and reduce fluctuations in loss experience through reinsurance.
Increased capacity	Underwriting expenses include direct and indirect costs that an insurance company pays to issue a policy. Generally, the lower these expenditures are as a proportion of premiums earned, the higher the profitability of the insurer. Through reinsurance, the reinsured (or ceding company) shares a portion of these underwriting expenses with the reinsurer, contributing to a higher profitability.
Catastrophe protection	Reinsurance offers catastrophe protection to cover financial loss from a single event (like a fire) as well as the aggregation of smaller claims from a single event (like an earthquake). Such protection reduces the loss experience to the insurer (Reinsurance Association of America, 2007).

Note: Excerpt from “Fundamentals of property and casualty reinsurance with a glossary of reinsurance terms,” by Reinsurance Association of America, 2007.

Creation of traditional reinsurance contracts

The reinsurance contract and included pricing may influence the behavior of primary insurance companies and the people they insure (Abramovsky, 2008). It is important to understand the creation and content of reinsurance contracts in order to understand this potential influence. The reinsurance contract is an agreement between the reinsurer and reinsured based on the business needs, and no two contracts are exactly alike. Two basic types of categories are generally used: treaty and facultative (Reinsurance Association of America, 2007). These types of reinsurance contracts are often combined.

A treaty is a reinsurance contract that often covers entire portions of risk that fall within their terms and may cover a long period of time. Treaty reinsurers do not review the individual risks and instead rely on the underwriting philosophy of the reinsured (Reinsurance Association of America, 2007). Treaties are also referred to as obligatory or automatic contracts. Facultative reinsurance contracts cover individual or unusual risk, and the reinsurer conducts its own risk review to analyze the potential severity of losses, determine the premium pricing, and whether or not to accept the risk (Abramovsky, 2008; Munich Re, 2010; Papenfuzz, 1964). Given the unique coverage, facultative reinsurance is often used to cover catastrophic risks and other low-incidence, high-risk loss risks.

Thorough risk models are essential to determine premiums and deductibles for coverage; these models may be proprietary to the company or contracted separately from a third party. If the reinsurer does not price risk of expected losses accordingly, they may reduce their potential profit. As stated previously related to insurance, reinsurance premium pricing can incentivize loss control or proactive efforts to mitigate risk by rewarding the ceding insurer with lower rates.

Both treaties and facultative reinsurance may be written on either a proportional or excess of loss basis, or a combination of both (Reinsurance Association of America, 2007). Proportional (or pro rata) reinsurance requires the reinsurer to pay for an agreed upon percentage of losses by the reinsured, while excess of loss reinsurance only occurs when the amount of loss is in excess an agreed upon amount. Proportional reinsurance is often used in property insurance because it provides catastrophic protection (Munich Re, 2010).

Types of traditional reinsurance

The type and amount of necessary reinsurance varies based in part on an insurer's exposure to different kinds of risk. Different categories of reinsurance include property, including coverage from natural catastrophes, fire, and wind; casualty or liability, including product liability or employers' liability insurance; and life and health, which are indirectly affected by catastrophic events. Property is the largest segment of the global reinsurance market, accounting for 38.5% of the market's total value. The Life Insurance segment accounts for a further 36.1% of the market (Market Line, 2013). A breakdown of the major categories is included in Table 5.

Table 5

Global reinsurance market category segmentation: million USD, 2012

Category	2012	%
Property	89.9	38.5%
Life Insurance	84.2	36.1%
Liability	55.0	23.6%
Financial lines	4.4	1.9%
Total	233.5	100%

Note: Excerpt from “Global reinsurance [Industry overview],” by Marketline, 2013

The category most likely to be influenced by climate change is property reinsurance. A subset of this is catastrophic property reinsurance, which “covers accidental losses resulting from damage to property of the insurer” from natural catastrophic events (Swiss Re, 2013c). Many major risks from climate change are covered under catastrophic reinsurance, and those with “exposures to natural catastrophe risks tend to rely particularly heavily on reinsurance” (Swiss Re, 2013c). Catastrophic reinsurance may also include coverage resulting from terrorism activities.

Overview of reinsurance providers

The reinsurance industry has a strong capital base, including an annual premium income of around 220 billion USD in 2011 and shareholder equity of about the same amount (Swiss Re,

2013c). This capital base allows reinsurers to take on the world's largest and most complex risks. Though the scale of the reinsurance sector itself is large, it is actually dominated by relatively few major companies and geographies. The ten biggest reinsurers account for two thirds or the market (Swiss Re, 2013c). Of those, four companies—Munich Re, Swiss Re, Hanover Re, and Lloyd's of London—generated 43.3% of the global market's share in 2012 (Table 6). The geographic segmentation of reinsurance is similarly concentrated—the Americas account for 51.9% of the global reinsurance market value and Europe accounts for a 36.2% of the global market (Table 7).

Table 6

Global reinsurance market share: % share, by value, 2012

Company	% Share
Munich Re	15.5%
Swiss Re	13.6%
Hannover Re	7.6%
Lloyd's of London	6.6%
Other	56.7%
Total	100%

Note: Excerpt from “Global reinsurance [Industry overview],” by Marketline, 2013

Table 7

Global reinsurance market geography segmentation: million USD, 2012

Geography	2012	%
Americas	121.2	51.9
Europe	84.5	36.2
Asia-Pacific	21.4	9.2
Rest of World	6.5	2.8
Total	233.6	100%

Note: Excerpt from “Global reinsurance [Industry overview],” by Marketline, 2013

Non-traditional insurance and reinsurance products

Traditional insurance and reinsurance indemnify the ceding party for losses, and pays out based on actual losses incurred depending on the terms agreed upon in the contract in exchange for premiums. This model is how the majority of ceding companies transfer risk, but non-traditional products offer additional methods of coverage. These include: parametric insurance, micro insurance, and catastrophe (CAT) bonds. These non-traditional products are being purchased more frequently from insurance and reinsurance companies as well as financial competitors as a way to reduce risk, especially in developing nations. These non-traditional products are not the focus of this research, but should be acknowledged as a way for the industry to transfer risk.

Parametric insurance

Parametric insurance is referred to as an index-based policy because it uses weather indexes, like precipitation, to determine payouts (Swiss Re, 2011). Unlike traditional reinsurance, which pays out only after losses are incurred and claims are filed, payment from parametric insurance occurs when local climatic conditions deviate from an agreed upon benchmark or index. The weather parameter (e.g., temperature or precipitation), benchmark (often informed by historic averages), degree of deviation, and payment amount are identified in the contract (Israel, 2013). Examples of deviation include less than expected rainfall during a drought or each time rainfall exceeds a chosen threshold over a set amount of time. The payment amount varies based on the amount deviation that occurs, and models aim to reflect the predicted damage on the ground (Swiss Re, 2011).

A benefit of the index-based contracts is that payment to the ceding party happens more quickly than traditional reinsurance. This is in large part because it excludes the need for damages to be assessed and claims filed. A quick payout is particularly valuable for developing countries that lack reserves and would otherwise have to rely on foreign aid to fund damage repair. This allows developing countries to return local societies and economies to their pre-disaster functions. It is similarly beneficial to the reinsurers because the payout has little case work and administrative costs. Parametric insurance can also be applied in places where insufficient data is available to support standard reinsurance risk analysis (Swiss Re, 2011).

Microinsurance

Microinsurance is similar to traditional insurance and reinsurance in that it offers protection against risks. However, the product is aimed at low-income individuals or businesses that do not qualify for larger scale coverage (Allianz, 2013; Warner et al., 2009). Allianz, an international financial services company that offers various forms of insurance and reinsurance coverage, established four criteria that are used to identify their microinsurance products from other products that similarly transfer risk: “1) insurance principles are applied, 2) product is based in a developing country or emerging market, 3) great majority (approximately 80%) of insured people or assets from low-income segment, and 4) product is based in a country that receives no more than 50% of government subsidies” (Allianz & GIZ, 2013). A product must fulfill all of these criteria to qualify as a microinsurance product. Due to limited asset value and data, micro insurance is typically based on a parametric model.

The social and business benefits of microinsurance are listed in Table 8. Though micro insurance premium prices are low, the market size is quite high. The world population includes 2.6 billion people with income ranging from 1.25 to 4 USD per day. This results in an estimated 40 billion USD potential from premiums per year (Swiss Re, 2010). In addition, through the aid provided through microinsurance companies, individuals may enter into higher wealth levels and eventually require classic insurance coverage (Allianz, 2013).

Table 8

Social and business benefits of micro insurance

Social benefits	Business benefits
Protecting vulnerable people	Driving innovation and cost efficiency
Expanding financial inclusion	Generating reasonable profits in the short term
Safe-guarding hard-won income gains	Branding opportunity

Note: Excerpt from “*Microinsurance at Allianz group: 2013 half year report*,” by Allianz, 2013.

Catastrophe bonds

Catastrophe, or CAT, bonds are the most common form of insurance-linked securities, and are a means of ceding insurance-related risk to the capital market (Swiss Re, 2011). CAT bonds are similar to parametric insurance in that payment is triggered by an index-based policy;

CAT bonds are different because they transfer from a reinsurance or insurance company to an investor in the capital market.

Risk holders or issuers (usually a government or insurance company) issue CAT bonds through an investment bank to private investors. The contract identifies index-based criteria that determine terms of payment. If the index-based event does not occur, then the risk holder pays the enhanced coupon to the investor for the term of the bond and receives principal back at maturity. If the risk holder suffers a loss determined by the index-based policy, then they are not obligated to pay interest and/or repay a portion of the principle (Risk Management Solutions, 2012). The avoided interest and principal would be used to pay out insurance policyholders. CAT bonds are high risk but still attractive to investors because they represent an asset class that is separate from the global financial market (Risk Management Solutions, 2012).

CHAPTER 3: AWARENESS OF RISK & PRICE OF RISK

The insurance industry plays an important role in raising awareness of environmental risk, including the predicted impact of climate change. Recall that insurers and reinsurers use complex modeling to predict loss from risk in order to price premiums appropriately. Many insurers forecast weather patterns using climate science in their models because past weather related disaster experience has proven to be an ineffective predictor of future losses (Mills, 2012; Thistlethwaite, 2012). Including such forecasting in models essentially puts a price tag on climate change, which can aid in increasing the awareness of the risk.

Risk based premiums are likely more expensive because they capture the appropriate magnitude of potential loss. This higher premium price can pass from a reinsurer to the primary insurer and finally to the original policyholder, where the loss physically occurs. In response to higher reinsurance premium rates, primary insurance companies may either reduce their reinsurance coverage or raise rates to policyholders. Reduced reinsurance coverage requires the primary insurer to absorb more risk, which may result in lower profits. Consequently, the insurer may try to reduce their cumulative level of risk by reducing primary insurance coverage availability, providing stricter terms to policyholders, or withdrawing from a location completely. This last option leaves the resident of that geography without private coverage and responsible for more loss, which may encourage government intervention of pricing or coverage. Alternatively, the company may decide to maintain the high level of risk but charge more from policyholders through higher primary insurance premium rates. Higher premium rates increase awareness of risk at the individual level—where the physical risk actually occurs. This financial cost may be a disincentive for more risk-prone locations and practices. The influence of risk based premium pricing to incentivize risk reduction behavior is described in Chapter 4.

Awareness beyond policyholders

The insurance industry has helped society understand and adapt to emerging risk through both policy prices and awareness through education (Mills, 2009). This can occur on a transactional basis from reinsurer to policyholder, described above, or at a greater scale by partnering with government and non-profit organizations to expand knowledge sharing beyond their policyholders.

The reinsurance company Swiss Re is a member of The Economics of Climate Adaptation Working Group (Working Group), a partnership of members from the public, private, and social sectors. The Working Group produced a report *Shaping Climate Resilient Development: A Framework for Decision-Making* that shares a practical analytical toolkit to aid decision-making and resource allocation for adaptation efforts in order to “operate our economies more efficiently and more consciously of the risks inherent in the climate forces around us” (Economics of Climate Adaptation Working Group, 2009). The framework includes tools to quantify a location’s total climate risk and evaluates measures to adapt to the expected risk using a cost-benefit discipline. Such measures include solutions from infrastructure, technology, and behavior. The Working Group recognizes that a larger purpose of the report is to help shift countries’ development paths towards greater climate resilience through adaptation. The report states that adaptation does not replace the need for reducing emissions, which is critical to reduce risk. Finally, the Working Group identifies roles of particular stakeholders, including the private sector that can, and do, provide services and products that provide climate risk management benefits. Cited as an example are insurance incentives for adaptation behavior. The Working Group partnership and report provide an opportunity to increase awareness of risk and should be replicated.

Risk awareness and financial indicators through insurance rates may be important incentives to change business and public behavior. Chapter 4 summarizes existing mitigation and adaptation behavior to reduce risk that is motivated in part through insurance industry pricing and incentives.

CHAPTER 4: PHYSICAL RISK REDUCTION

In addition to transferring financial risk from the insured, the insurance industry may also be able to reduce the magnitude of loss from physical risk by incentivizing different behavior. The Intergovernmental Panel on Climate Change (IPCC) states “insurance and other forms of risk transfer can be linked to disaster risk reduction and climate change adaptation by enabling recovery, reducing vulnerability, and providing knowledge and incentives for reducing risk” (2012, p. 525). Risk reduction is beneficial to the insurance industry because it decreases the potential magnitude of loss, increases risk predictability, and could help to preserve insurability of high-risk areas (Geneva Association, 2013b; Mills & Lecomte, 2006).

The previous chapter describes how the insurance and reinsurance sectors raise awareness of risk through models and by assigning a price to risk. Both are important factors to encourage risk management behavior that reduces physical risk. This chapter outlines ways in which the insurance industry currently helps to reduce the magnitude of loss from physical risk by incentivizing disaster risk mitigation efforts by policyholders and through the industry’s own advocacy and investments towards climate change mitigation. Before continuing, it is helpful to define related but different terms commonly used to describe risk reduction (Table 9).

Table 9

Definitions from the IPCC related to risk reduction

Term	Definition
Mitigation (of climate change)	A human intervention to reduce the sources or enhance the sinks of greenhouse gases to reduce the rate of climate change.
Mitigation (of disaster risk and disaster)	The lessening of the <i>potential</i> adverse impacts of physical hazards (including those that are human-induced) through actions that reduce hazard, exposure, and vulnerability, including the use of different disaster risk management measures.
Adaptation	In human systems, the process of adjustment to <i>actual</i> or <i>expected</i> climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate.
Disaster risk management	Processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster

	preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, resilience, and sustainable development. Disaster risk management can be divided to comprise two related but discrete subareas or components: disaster risk reduction and disaster management.
Disaster risk reduction	Denotes both a policy goal or objective, and the strategic and instrumental measures employed for <i>anticipating</i> future disaster risk, <i>reducing</i> existing exposure, hazard, or vulnerability, and <i>improving</i> resilience. This includes lessening the vulnerability of people, livelihoods, and assets and ensuring the appropriate sustainable management of land, water, and other components of the environment.
Disaster management	Social processes for designing, implementing, and evaluating strategies, policies, and measures that promote and improve disaster preparedness, response, and recovery practices at different organizational and societal levels

Note: Excerpt from “*Managing the risks of extreme events and disasters to advance climate change adaption,*” by Intergovernmental Panel on Climate Change, 2012, pages 556-561

The business motive for reducing physical risk

Insured catastrophe losses are growing faster than premiums, populations, and gross domestic product in the United States (Mills, Roth, & Lemote, 2005). As mentioned in Chapter 3, in order to reduce their risk of financial loss, insurance and reinsurance companies may withdraw from high-risk areas, raise premium prices, or limit coverage terms. These reactions could ultimately lead to a decreased business and criticism from consumers, investors, and regulators (Mills & Lecomte, 2006). The insurance industry acknowledges that a more proactive approach, like disaster risk management and mitigation strategies, is necessary to make risk more predictable and minimize losses. Swiss Re observes, “financing risk after the event has occurred (e.g. by issuing debt, raising taxes, relying on international aid) is becoming unsustainable given the magnitude of disasters and the growing risk exposure” (Swiss Re, 2009).

The insurance industry can incentivize risk management by sending financial signals through coverage availability, terms, and pricing (Mills, 2007). Higher premium prices can prove a disincentive to development in high-risk geographies. Conversely, parties that improve disaster resilience may be offered lower premium rates.

Encouraging behavior that results in lower physical risk and possibly lower premium prices may seem counterintuitive, especially since premiums are assets on the insurers’ financial balance sheets. The business rationale for encouraging lower physical risk is twofold. The first has to do with risk prediction. If the expected loss can be more confidently predicted because of

mitigation efforts like building codes, insurance and reinsurance companies can reduce unforeseen losses and more confidently set lower premium prices for the given risk. The second rationale is because of competition between companies. If Company A has a better understanding of potential risk than Company B, they will likely demand a higher premium price from the ceding party. As a result, Company B may appear more attractive than Company A because of the lower premium. Accepting a lower premium price than the risk based amount does not make sense for Company A if the risk remains the same, but if the company can encourage risk reduction behavior by the insured party then they may be able to reduce the overall risk. Upon successful implementation of this behavior, Company A can offer reduced premium rates to the insured party thus making them more or equally attractive compared to Company B. In the long run, any company that fails to acknowledge the true price of risk will be unsuccessful.

Ways the insurance industry currently reduces physical risk

The insurance industry recognizes that reducing the magnitude of loss from physical risk is critical to ensure risks remain insurable. As such, they play an active role in reducing physical risk by advocating new regulations and incentivizing mitigation. The list below captures some of the ways that the industry already reduces risk.

1. Improvements to building and infrastructure codes & standards
2. Awareness of land use impact
3. Climate change advocacy to reduce emissions
4. Self regulation of the industry
5. Financing of emissions reducing technology and projects

This list is by no means intended to be an exhaustive overview of how the insurance and reinsurance sectors can reduce physical risk. Excluded from mention in this chapter is the important role of non-traditional products, especially microinsurance and CAT bonds, to increase mitigation and reduce risk to society in developing countries. The importance of these products is growing as populations increase in developing countries globally.

1. Improvements to building and infrastructure codes and standards

Building and infrastructure codes establish a regulated standard to protect the public's safety, health, and general wellbeing. According the Federal Emergency Management Agency (FEMA)(2014b), modern building codes are fostered by four entities: “the insurance industry who promotes the establishment of standards to minimize accidents/claims; social organizations who look to eliminate squalor and impact on health; local governments who develop regulations to deliver health and safety to taxpayers; and disasters.” The insurance industry promotes commercial and residential building standards to mitigate the loss of physical damage. The Insurance Institute for Business & Home Safety (IBHS) is made up of insurer and reinsurer members and encourages building codes and standards in the United States. Through their *Rating the States* report, the IBHS evaluates and compares regulations and processes in the 18 states at highest risk of hurricanes. The report is intended to raise transparency of existing state building codes and advocate for updated codes (2013).

Absent legislation, the industry can use price as a persuasive instrument to promote stronger buildings on safer sites (Geneva Association, 2013a). A successful example is the California Earthquake Authority, a public-private cooperation between state insurance and private companies. Property owners pay lower premiums when they take measures to retrofit structures to prevent earthquake damage (Geneva Association, 2013a).

2. Awareness of land use impact

Land use refers to both a set of human actions in a certain land cover and “the social and economic purposes for which land is managed (e.g., grazing, timber extraction, and conservation)” (IPCC, 2013, p. 561). Land use management decisions can result in different exposure to physical risk. One significant decision is *where* development occurs. Insurers use models to highlight different physical risk and can put a price on a location. In addition to advocating for building codes, the IBHS “encourages better decision-making about where we build in regard to natural hazards” (Institute for Business & Home Safety, n.d.). Absent legislation, insurers can predict location of high risk and increase coverage rates.

Different land use purposes (e.g., grazing, timber extraction, and conservation) also offer different mitigation and adaption benefits. The benefits vary from sequestered carbon in soils and enhanced drought resistance from agricultural soil management, to reduced wildfires and fire

risk from improved forest management. Land use management decisions impact nearly every type of insurance type (property, health, etc.) (Mills, 2007). The industry seeks to understand the mitigation and adaption benefits of such decisions to offer protection from physical risk.

3. Climate change advocacy to reduce emissions

Insurance and reinsurance companies are outspoken about the impact of climate change and the need to reduce emissions, and regularly engage in proactive public policy discussions to encourage government intervention (Mills, 2009). The Reinsurance Association of America (2008) encourages efforts to mitigate human-induced greenhouse gases broadly and evaluates emissions reduction measures in the operations of its partner organizations. Lloyd's and Swiss Re both identify climate change as the reinsurance industry's number one issue (Thistlethwaite, 2012).

Advocacy extends beyond the efforts of individual companies. Thirty-seven insurance and reinsurance companies participate in ClimateWise, a voluntary initiative to leverage the industry's technical and political authority to offer a "more pro-active and collaborative effort to reduce the risk of climate change" (ClimateWise, n.d.). Members commit to action identified in their six principles: "1) lead risk analysis, 2) inform public policy making, 3) support climate awareness amongst customers, 4) incorporate climate change into investment strategies, 5) reduce the environmental impact of business, and 6) report and be accountable" (ClimateWise, 2011). Such commitments has resulted in action—independent auditors found 88% of ClimateWise members comply with these principles and have well-established activities that support management and assessment of climate risk. Such partnerships strengthen the collective voice of the industry.

4. Self-regulation in the industry

Some companies within the insurance industry self-regulate to ensure others apply good modeling and set prices that accurately reflect the true risk. ClimateWise, introduced previously as contributing to climate change advocacy, is also an example of a self-regulating institution. The six principles that govern the practices of the 37 companies are certainly important, but the

potential of ClimateWise to influence the broader insurance industry to expand their authority in global climate change governance is perhaps of equal importance.

Self-regulation is generally motivated by practical business sense. Reinsurance and insurance companies offer closely substitutable output—risk management expertise (Thistlewaite, 2012). Such expertise is generally informed by similar modeling and underwriting processes, so when information is revealed about a single insurance or reinsurance company, it reflects to some degree on all companies (Barnett & King, 2008). Though this can be both positive and negative, it is the harm from a bad decision of a single company that is often more impactful. For example, if a company makes a mistake or uses insufficient data to model a risk, they may price their premium too low to reflect the actual cost of the risk. This may lead to insolvency, when the company can no longer meet its financial obligations to policyholders when debts (in the forms of claims) become due.

Such a negative example reflects poorly on the industry as a whole. To avoid this negative industry-wide impression, companies may develop a self-regulatory institution to generate strategies (Barnett & King, 2008). The benefit of the ClimateWise institution is that the emerging leaders in the industry encourage other companies to work towards similar standards as outlined in the six principles, including quality of data and risk analysis. This peer pressure of sorts ensures that all companies apply the same rigor to pricing premiums. These standards benefit the broader industry and increase the scale of potential impact.

5. Financing of emissions reducing technology and projects

The insurance industry supports emerging technology and emissions reducing projects by transferring financial risk, which can encourage different sources of financing. One example is insuring emissions trading markets. Major emissions trading projects developers try to forward-sell carbon credits to capitalize their projects, but buyers are often unwilling to pay full price due to the uncertainty of delivery. A reinsurance policy can cover the risks associated with non-delivery, so financial institutions are more likely to lend to developers to begin projects. This has the dual benefit of adding a new premium stream for the reinsurance company and allowing capital to help emissions project developers fund their work (Burchell, 2010). Insurance coverage may not physically reduce emissions, but it does provide necessary financial support for projects that reduce the emissions sources or enhance the sinks of greenhouse gases to

proceed. This increases the number of projects that aim to decrease emissions and the rate of climate change.

CHAPTER 5: RECOMMENDATIONS FOR THE INSURANCE INDUSTRY

The insurance industry is positioned to influence the behavior of nearly every sector globally due to their influence over ceding insurers and policyholders. Chapters 3 and 4 highlight ways in which the industry already raises awareness of risk, quantifies the true cost of risk, and reduces physical risk through mitigation and adaptation. This chapter offers additional recommendations to the industry to further reduce potential risk while still being mindful of a company's bottom line. The recommendations to follow include emerging actions and partnerships from the industry that occur infrequently and should be replicated. The examples provided highlight, at a small scale, the impact and business benefit of the recommended behavior or engagement. Challenges that threaten each of these recommendations are discussed in Chapter 6.

1. Public/private partnerships

Implementing risk management practices at a large scale can be challenging because it requires the cooperation of multiple actors to coordinate and fund projects (Geneva Association, 2013a). Partnerships between the public government and private insurance companies can encourage risk management at a large scale. Governments are well positioned to fund large-scale mitigation projects because of their responsibility to manage infrastructure and the existing financial structure through state and federal taxes (Luke & Abramovsky, 2011). Public infrastructure can include transportation, water, energy, and waste systems and is vital to economic development and prosperity. It can be funded publicly, privately, or through public-private partnerships to cover the high investment cost. The Geneva Association (2013a), a leading international think tank of the insurance industry, recommends that governments “consider privately insuring public infrastructure” and “employ insurance industry expertise in engaging in disaster reduction measures” (p. 10). More formal partnerships between private companies and public agencies should be put in place to improve solvency of public insurance programs, increase the occurrence of risk management practices, and increase the pool of people who have access to coverage.

Private reinsurance for public coverage

Private reinsurance may be able to improve the solvency of public insurance programs. A study commissioned by the Congressional Budget Office in 2002 analyzed proposed policies that would enact federal reinsurance for natural disasters and terrorism risks (Torregrosa, 2002). The 2002 study found that federal reinsurance proposals would be costly to taxpayers and “unlikely to provide an adequate cushion against losses” (p. 24). Analysts also recognized that the federal government has had difficulty managing risk effectively through aid programs, in part because they are obligated to provide assistance to those at risk regardless of whether or not they purchased coverage. This makes it more challenging for the government to enforce risk based premium prices. It is the author’s opinion that disadvantages of federal reinsurance outweigh the advantages identified in the study and that reinsurance from private companies should instead be pursued. Though the analysts of the Congressional Budget Office study did not make a formal conclusion, they did suggest other federal policies to promote the supply of insurance including: offering federal incentives for risk mitigation, reducing federal assistance after disasters, changing the tax treatment of loss reserves held by insurers, and limiting damage awards. These suggestions should be encouraged in the public/private partnership.

Especially in the near term, private reinsurance may be better suited at a smaller scale, like a state or city, rather than at the federal level (C. McHale, personal communication, April 24, 2014). One example is between the Alabama State Insurance Fund (SIF) and reinsurer Swiss Re (Swiss Re, 2011). In 2010, Alabama became the first state to purchase parametric coverage, a non-traditional form of reinsurance that transfers natural catastrophe risk to the private party using index-based triggers. The contract, which ended in 2013, confirmed that SIF would receive financial compensation in the event that a Category 3 hurricane passed through a designated area of exposed coast. Neither a follow-up report on the partnership nor an update about whether a new contract is in place has been shared to date.

The partnership between Swiss Re and SIF provides an example of how public reinsurance can cover public programs. Governments should pursue such coverage in order to protect public infrastructure to strengthen public insurance programs and ultimately to improve the well-being of society following disasters.

Encourage government incentives to promote risk reducing activities

A partnership between private insurance and public governments can benefit the government, public, and insurer. The insurance company provides much needed liquidity to speed up private reconstruction following a disaster in exchange for a risk based premium paid by the government. This premium cost may incentivize the government to encourage more risk reducing action by both the public and government.

An important and necessary action that needs to be taken by the government is the creation and regulation of stronger building codes to ensure infrastructure and buildings are rebuilt to appropriate standards after a disaster. The government may also consider incentivizing mitigation efforts by offering tax credits to residents that prove successful completion of mitigation projects. The payment mechanism could be similar to that of The Energy Policy Act, which provides federal tax credit to residents that install renewable energy units like solar electric and wind-energy systems (U.S. Department of Energy, n.d.). A government mitigation incentive would also require a certification process and official entities endorsed by a state or local government to ensure the validity of the residential mitigation project, similar to the approval process of renewable energy projects for the Energy Policy Act.

Governments should offer more incentives to catalyze risk reduction in order to create more resilient communities. This would decrease physical risk to protect communities and reduce the magnitude of damages that the government would have to reimburse following a disaster.

Increase cross-sector collaboration

Large scale changes to building codes and standards often require new partnerships between the private insurance industry and government agencies, which can be a challenging and slow process. The *Building Climate Resilient Cities* model to catalyze cross-sector collaboration to improve climate resilience in cities provides a framework. A partnership of six organizations designed and developed a workshop series to insurance industry members and city stakeholders in Boston, San Diego, and Toronto. The series introduced a process for parties to identify shared priorities and collectively settle on a local area for comprehensive risk management (Brugmann, 2013, p. 8). The goal of the workshop was to identify areas of mutually beneficial collaboration with an aim to reduce risk. No follow-up material has been published to date to track progress

within each of the three cities or other locations that applied the Insurer-City Resiliency Toolkit. Capturing the progress and lessons learned will be important to update and replicate the series.

The *Building Climate Resilient Cities* method highlights a way to unify different parties around a shared mitigation goal to increase the rate of resilience and disaster preparedness. Given the magnitude of potential risk, this collaboration is critical to expedite large-scale risk reduction and should be replicated.

2. Risk models

Increase accessibility of data and models

An insurance or reinsurance company may raise awareness of risk by offering greater transparency of data. As discussed in Chapter 2, complex models are essential to estimate risk and set a premium price. These models are often either created by a separate party and sold to the insurer, or created by insurers for their exclusive use. Regardless of origin, the model results and proper analysis to assess risk distinguish companies from their competitors. This is in part why the industry has been operating on closed, proprietary data formats with little transparency to the client or public. This lack of information creates disconnect between the price of risk and a deeper understanding of the actual risk; this deeper understanding that is necessary to incentivize a change of high-risk behavior.

Some reinsurance companies that create their own models are increasing transparency by sharing data and models with clients. Munich Re's Natural Hazard Assessment Network (NATHAN) allows primary insurance clients to assess the natural hazard exposure of single risks and access the latest map and satellite images at any time (Munich Re, 2012). Similarly, Swiss Re provides CatNet, a database that combines natural hazard information with Google maps and satellite imagery, to clients free of charge (Swiss Re, 2013b). The benefits of CatNet, as stated by Swiss Re, include: "1) swift hazard checks for regions that are unfamiliar to clients; 2) access to tailor made maps and satellite images; 3) the ability for clients to import location data to illustrate risk exposures combined with natural hazard data; 4) country-specific insurance conditions, claims experience, and natural disaster loss dimensions; and 5) recognition of footprints of major catastrophes" (Swiss Re, n.d.).

Other companies and partnerships offer information publicly or not for profit. In addition to offering NATHAN to clients, Munich Re publically offers NatCatSERVICE, a database of statistics on previous natural catastrophes, and Touch, an information portal that offers detailed information and knowledge (Munich Re, 2011; n.d.). Another innovative example of data sharing is the Oasis Loss Modeling Framework (Oasis), an open framework for catastrophe modeling for developers. Oasis is a not-for-profit company owned by members who come from the insurance and reinsurance community. It promotes a single format for different peril types (e.g., wind, flood, earthquake, etc.) so that the risk information can be added together into a single model. Oasis is currently only available to paying members, the price for which is expected to drop when additional members join. Oasis acknowledges that insurers still must carryout their validation exercises and document that the models are sufficient per standard solvency regulation (World Risk and Insurance News, 2014). Nonetheless, this open format and relatively cheaper model broadens the potential users to include policy makers and public members, and creates an opportunity for faster data updating from the academic community and other modelers.

Both client-privileged models and public models are valuable; the latter could have a greater impact, though it is more challenging to fund and currently lacks the same level of data. Availability of models and data should be increased to improve transparency of risk and associated prices to facilitate greater understanding and motivate physical risk reduction.

Improve quality of data and risk analysis through collaboration with non-profits and government

In addition to making data and models more available, the insurance industry and modelers should also improve their data and risk analysis. The insurance industry must evaluate losses based on expected future weather and catastrophe patterns because past experience is insufficient to predict future risk (Geneva Association, 2013b). Critics suggest the data to predict future weather and catastrophe patterns is insufficient, that knowledge gaps exist, and that prevailing underwriting practices do not reflect long-term projected risks (Economics of Climate Adaptation Working Group, 2009; Urban Land Institute, 2013). In particular, the frequency and severity of thunderstorms, hailstorms, and tornadoes need to be better understood (McHale & Leurig, 2012). Updating data and risk analyses is important so that a company can understand

and then price risk appropriately to reduce loss, but the financial investment for data is significant and companies have limited capital and a desire to minimize underwriting costs.

A cost-effective recommendation to improve the quality of data and risk analysis is to increase collaboration and data sharing between the private insurance industry and non-profit climate-modeling scientists and organizations (McHale & Leurig, 2012; Mills, 2007). However, contributing to a private company's model for the purposes of financial gain may compromise the tax-exempt status of an organization. Under section 501(c)(3) of the Internal Revenue Code, an organization exempt from taxes must be "operated exclusively for religious, charitable, educational, scientific" or other exempt purposes (Megosh, Scollich, Salins, & Chasin, 2001). Information and data from a tax-exempt organization must be used in some way to advance their charitable purposes and not primarily to enable a private party to use that information for private gain (Chan, 2012). This reaffirms the recommendation to make models publically available for the purposes of education, which may enable more non-profit partners to contribute additional scientific data.

The not-for-profit Oasis Loss Modeling Framework, mentioned above, has the potential to improve risk data and make it more available by providing a more open platform. Additional non-profits not associated with the insurance industry are already seeking to improve data and expand knowledge of risk. A new project called Risky Business seeks to assess the economic risk the United States faces from the impacts of unmitigated climate change and plans to release a report in June of 2014. The project is funding an independent risk assessment that combines "existing data on the current and potential impacts of climate change with original research that will quantify potential future costs" (Risky Business, n.d.). The second component of Risky Business is an engagement effort to target the "economic sectors most at risk from a changing climate, and begin the process of helping leaders from across these sectors prepare a measured response" (Risk Business, n.d.). Though the level of detail and accessibility of the Risky Business data is unclear from the media material, it may provide an additional opportunity for partnership to improve models.

Finally, the insurance industry and members of the public should encourage governments to contribute to data and risk analysis. Governments can stimulate the publically funded academic sector to improve risk analyses and models and then make data freely available to risk professionals (Geneva Association, 2013a). This combines resources for better data collection

with a public venue to spread awareness broadly. The partnership between public programs and private reinsurers may motivate this data investment, especially if it reduces premium prices to the public program.

Ultimately, better data is essential to assess risk and encourage changed behavior. Without it, parties will not be motivated to take action. The insurance industry should increase partnerships with non-profits and the government to improve data.

Include green infrastructure resilience solutions in risk modeling

The industry recognizes the impact of different land use in terms of location and practices, but should focus greater attention on the potential of green, or natural, infrastructure to increase resilience. Green infrastructure relies on natural processes in addition to or in place of gray infrastructure (including dikes, levees, and sea walls) to mitigate physical risk. Models estimate the impact of gray infrastructure, but lack data on the impact of land use decisions and natural infrastructure. To increase the accuracy of models and better understand risk, the positive impact of existing and potential green infrastructure should be included (Dow Chemical, et al., 2013).

One partnership is seeking to do just that. Swiss Re and other private and non-profit partners produced a joint-industry white paper to explore the impact of planned and managed natural and semi-natural systems to increase business resilience to external economic and environmental stressor. One of the four key recommendations of the paper was for organizations to change the economic and environmental footprint analysis so that benefits of green infrastructure can be better recognized (Dow Chemical, Swiss Re, Shell, Unilever, & The Nature Conservancy, 2013). The white paper did not confirm how the results would be integrated into existing models or how the models would be shared.

More models should include the resilience benefits of green infrastructure. Including these provides a more accurate prediction of risk, awareness of existing resilience, and will inform appropriate additional mitigation efforts.

3. Impact investments

The insurance industry is a major global investor and can invest in green bonds as a way to mobilize “private capital to fund climate change mitigation and adaptation projects” (Reichelt, 2010). Green bonds are fixed income investments that provide capital for products with environmental benefits (JPMorgan Chase, n.d.). The World Bank was the first entity to issue green bonds in 2008, and has since issued over 5.6 million USD in green bonds (World Bank Treasury, n.d.).

Green bonds are an example of impact investments, or investments designed to create positive impacts as well as financial return (Saltuk, Bouri, Leung, 2011). The Global Impact Investing Network, a nonprofit organization dedicated to increasing the scale and effectiveness of impact investing, defines impact investing by the following four core characteristics:

- **“Intentionality:** The intent of the investor to generate social and/or environmental impact through investments is an essential component of impact investing.
- **Investment with return expectations:** Impact investments are expected to generate a financial return on capital and, at a minimum, a return of capital.
- **Range of return expectations and asset classes:** Impact investments generate returns that range from below market (sometimes called concessionary) to risk-adjusted market rate
- **Impact measurement:** A hallmark of impact investing is the commitment of the investor to measure and report the social and environmental performance and progress of underlying investments. Impact measurement helps ensure transparency and accountability, and is essential to informing the practice of impact investing and building the field” (Global Impact Investing Network, n.d.).

In November of 2013, Zurich Insurance Group committed to spending as much as 1 billion USD on green bonds, the largest investment in green bonds globally (Zurich, 2013). The potential of green bonds and other impact investing is significant, but requires greater transparency and disclosure absent official guidelines. Private financial institutions collaborated to create Green Bond Principles, which outline voluntary process guidelines for issuing green bonds, and are a step in the right direction (JPMorgan Chase, n.d.).

The insurance industry should adjust their investment portfolio to include more green bonds. The projects funded by green bonds can reduce risk through investment in more resilient land uses or restored environments. Green bonds and impact investments highlight an important way the industry can reduce physical risk as an investor and simultaneously increase profit.

4. Disaster risk reduction services

Insurance alone will fail to reduce risk unless it is implemented along with mitigation measures (Warner, 2010). Providing mitigation solutions to reduce risk is essential to the protection motivation theory to change behavior (Bubeck et al., 2012). Recall from Chapter 1 that the coping appraisal is the stage after an individual feels threatened, that involves thinking about benefits of possible actions and evaluation of competencies to carry them out. It is critical that an individual or corporation be aware of possible solutions to reduce the threat. This coping appraisal, rather than the threat appraisal (i.e, risk perception) is a greater predictor of protective response behavior (Maddux & Rogers, 1983). Insurance providers can contribute to both appraisal stages by raising awareness of risk and offering solutions through risk management services.

The insurance industry already provides such services to clients, but faces two challenges that limit the scale of impact. First, data availability and risk assessment information varies by geography, especially in developing countries. Different locations may also present education and language barriers that may lead to ineffective implementation (Warner et al., 2009). Second, though the service already exists, the demand from consumers is relatively low (C. McHale, personal communication, April 24, 2014). This may be in part due to a perception that governments and not individuals and corporations are responsible for reducing risk.

The insurance industry should increase their risk management services to clients to offer solutions and motivate risk resilient behavior. Insurance and reinsurance companies benefit from these services by selling additional expertise and making high-risk areas more insurable. In order to increase demand for disaster risk reduction services, the industry should educate consumers of the benefit of taking such efforts or make reduction measures a prerequisite for insurance coverage.

Summary

These recommendations apply to the broad insurance industry, including both insurance and reinsurance. Those interested in modifying the overall industry should consider the influence of reinsurance companies specifically because they are an important lever to influence the pricing and behavior of ceding insurers. Though the scale of the reinsurance sector itself is large, it is actually dominated by relatively few major companies and geographies. The ten biggest reinsurers account for two thirds of the market, with four of those ten accounting for nearly half of the global market share in 2012 (Marketline, 2013; Swiss Re, 2013c). Given the potential of self-regulation, changing behavior of these four companies may have an even greater effect. The reinsurance sector is also regulated less than primary insurance companies, generally not beyond the risk of defaults of insolvencies.

CHAPTER 6: CHALLENGES

There are several challenges to the opportunities to influence additional pro-environmental behavior identified in Chapter 5. Recognition and resolution of each of these challenges is essential for the industry to have a greater impact.

Risk premium prices may not change behavior of ceding companies or individual policyholders

One assumption throughout this research is that the risk based premium prices will reduce high-risk behavior by policyholders. However, policyholders may react to higher premium prices by pursuing coverage from a different insurer, dropping coverage altogether, or accepting the higher rate without changing behavior. The first reaction discourages industry members to change their premiums to reflect the true cost and decreases the overall rate of influence. The second reaction, to drop coverage altogether, puts the collective society at greater risk and increases the likelihood of government intervention, described below. The third reaction, to pay the higher rate without changing behavior, is a possible scenario that will vary by individuals' budgets. More research needs to be done to understand the financial threshold of different socio-economic groups to incentivize action.

Government intervention may prevent risk based premiums

Governments can both promote and hinder the contributions of the insurance industry. The public/private partnerships described in Chapter 5 identify positive opportunities to build better models and change behavior through government incentives. However, government intervention that interferes with risk based premiums prevents a healthy, private insurance market (Ceres, 2010; Lloyds, 2011). Risk based premiums are essential to raise awareness and to change behavior to reduce the magnitude of loss from risk. ClimateWise recognizes the importance to accurately assess and price the risks associated with climate change and regards such action as “critical to the development of climate resilience and adequately adapted lower carbon economy” (2011).

Unfortunately recent political decisions in the United States have shown disappointing progress. President Obama signed the Homeowner Flood Insurance Affordability Act of 2014 into law on March 21, 2014. This law repeals and modifies provisions of the Biggert-Waters Flood Insurance Reform Act, which encouraged risk based premium pricing for the Federal Flood Insurance Program (Federal Emergency Management Agency, 2014a).

Competing risk transference or reducing products may create competition

Non-traditional insurance products, like CAT bonds and microinsurance, have the ability to detract business from traditional reinsurance companies unless the industry incorporates them into their portfolios. Companies should embrace these innovative new products and adjust practices and expertise accordingly to offer it along with other traditional coverage. Doing so requires additional upfront costs, but will keep them nimble enough to adjust to different consumer demands. This may also provide an opportunity for non-traditional partnerships to provide data in developing countries.

CHAPTER 7: CONCLUSION

Increased risk from climate change is likely to impact every individual to some degree. How we respond to reduce risk now will impact our future economies and societies. The insurance industry is commonly regarded as the industry best able to reduce and spread financial risk. Their business of reducing financial risk to policyholders has raised awareness, assigned an economic value to risk, and resulted in climate change advocacy, as well as mitigation and adaptation to reduce physical risk. The industry has proven to be a critical influencer to encourage risk-adverse behavior and regulation, and will continue to do so; the recommendations listed in Chapter 5 offer ways to broaden this influence.

However, the insurance industry alone cannot enact necessary change. The recommendations to the industry emphasize the importance of collaboration with non-profits organizations, governments, the scientific community, and industry peers. In order for such collaborations to be successful, it is necessary to understand the motivations and limitations of each party and explore shared priorities. Partnerships that encourage honest exchanges and embrace a collaborative spirit are critical to address the potential global risks to come. Equally important is recognizing the need for different communication messages and methods to share risk information, offer solutions to reduce risk, and confirm incentives. While private businesses may be motivated by protecting supply chains to ensure share prices, rural farmers may be more interested in the ability to predict and adapt to varying rainfall to ensure their family's continued wellbeing. Each motivation is valid and should be addressed to enact risk-adverse behavior change.

Collaboration requires a catalyst to unite partners. The party with the most to gain or the most to lose often serves as catalyst; the insurance industry has and will likely continue to step up to this role. As the ultimate accumulators of risk, the insurance industry may have much more to lose as climate change progresses. Though it cannot singularly prevent risk from climate change, the insurance industry is uniquely poised to significantly influence the world's response. Private and public entities should continue to partner with and encourage the industry to pursue innovative solutions to reduce the financial and physical risk caused by climate change. Ultimately, this will not eliminate risk, but it may avert the magnitude of impact from catastrophes on our societies and economies.

REFERENCES

- Abraham, K. S. (1986). *Distributing risk: Insurance, legal theory, and public policy*. New Haven: Yale University Press, c1986.
- Abramovsky, A. (2008). Reinsurance: The silent regulator?. *Connecticut Insurance Law Journal*, 15 345.
- Allianz. (2013). *Microinsurance at Allianz group: 2013 half year report*. Retrieved March 20, 2014 from https://www.allianz.com/v_1381221496000/media/responsibility/documents/microinsurance_business_update_2013.pdf
- Allianz & GIZ. (2013, April). *Microinsurance definition and assessment tool*. Retrieved March 20, 2014 from https://www.allianz.com/v_1364458619000/media/responsibility/documents/Allianz_Microinsurance_Definition_and_Assessment_Tool_April2013.pdf
- American Management Association. (1964). Reinsurance: Methods, markets, and economics. *Management Bulletin*, 39, 37-44.
- Barnett, M., & King, A. (2008). Good fences make good neighbours: A longitudinal analysis of an industry self-regulatory institution. *Academy of Management Journal*, 51, 1150-1170.
- Brimble, M., Stewart, J., & de Zwaan, L. (2010). Climate change and financial regulation: Challenges for the financial sector following the global financial crisis. *Griffith Law Review*, 19(1), 71-85.
- Brugmann, J. (2013, November). *Building resilient cities—From risk assessment to development*. Retrieved from Ceres website: <http://www.ceres.org/resources/reports/building-resilient-cities-from-risk-assessment-to-redevelopment>
- Bubeck, P. P., Botzen, W. W., & Aerts, J. H. (2012). A review of risk perceptions and other factors that influence flood mitigation behavior. *Risk Analysis: An International Journal*, 32(9), 1481-1495. doi:10.1111/j.1539-6924.2011.01783.x
- Burchell, S. (2010, September). *Part of the solution*. *Reinsurance*, 12. Retrieved from http://www.parhelion.co.uk/pdf/S_Burchell_Reinsurance_Sept_2010.pdf
- Ceres. (2010, April). *Climate change risk perception and management: A survey of risk managers*. Retrieved from <https://www.ceres.org/resources/reports/risk-manager-survey/view>

- Chan, E. (2012, September 27). *Private benefit rules—Part 1: Private benefit doctrine* [Web blog post]. Retrieved from <http://www.nonprofitlawblog.com/private-benefit-rules-part-i-private-benefit-doctrine/>
- ClimateWise. (n.d.) *What is ClimateWise?*. Retrieved on March 17, 2014, from <http://www.climatewise.org.uk/about/>
- ClimateWise. (2011). *ClimateWise Principles: The fourth independent review 2011*. Retrieved from <http://www.climatewise.org.uk/storage/fourth-year-review-2011/ClimateWise%20Fourth%20Year%20Review%20-%20Full%20Report.pdf>
- Dobler, M., Lajili, K., & Zéghal, D. (2012). Environmental Performance, Environmental Risk and Risk Management. *Business Strategy & The Environment (John Wiley & Sons, Inc)*, 23(1), 1-17. doi:10.1002/bse.1754
- Dow Chemical, Swiss Re, Shell, Unilever, The Nature Conservancy. (2013, June). *The case for green infrastructure*. [White paper]. Retrieved January 10, 2014, from <http://www.nature.org/about-us/the-case-for-green-infrastructure.pdf>
- Economics of Climate Adaptation Working Group. (2009). *Shaping climate-resilient development: A framework for decision-making*. Retrieved from http://ec.europa.eu/development/icenter/repository/ECA_Shaping_Climate_Resilient_Development.pdf
- Federal Emergency Management Agency. (2014a). *Flood insurance reform: Homeowner flood insurance affordability act*. Retrieved from <http://www.fema.gov/flood-insurance-reform>
- Federal Emergency Management Agency. (2014b). *Introduction to building codes* [PowerPoint slides]. Retrieved from <http://www.fema.gov/media-library-data/04e952f7c7f8ec6e52d1afbe0394c955/Introduction+To+Building+Codes+PP+T-New+Brand.pdf>
- Geneva Association. (2013a). *Insurers' contributions to disaster reduction—a series of case studies*. Retrieved from https://www.genevaassociation.org/media/607750/ga-2013-geneva_report-7.pdf
- Geneva Association. (2013b). *Warming of the oceans and implications for the (re)insurance industry*. Retrieved from https://www.genevaassociation.org/media/616661/ga2013-warming_of_the_oceans.pdf
- Global Impact Investment Network. (n.d.). *About us*. Retrieved April 30, 2014 from <http://www.thegiin.org/cgi-bin/iowa/aboutus/index.html>
- Greene, M.R. (1971). *Risk aversion, insurance, and the future*. Bloomington, Indiana: Graduate School of Business, Division of Research, Indiana University.

- Insurance Information Institute. (n.d.) *Investments*. Retrieved May 1, 2014, from http://www.iii.org/facts_statistics/investments.html
- Hoeppe, P., & Gurenko, E. N. (2006). Scientific and economic rationales for innovative climate insurance solutions. *Climate Policy* (Earthscan), 6(6), 607.
- Insurance Information Institute. (n.d.) *Investments*. Retrieved May 1, 2014, from http://www.iii.org/facts_statistics/investments.html
- Insurance Institute for Business & Home Safety. (2013, August). *Rating the states: An assessment of residential building code and enforcement systems for life safety and property protection in hurricane-prone regions—Midterm update*. Retrieved from http://www.disastersafety.org/wp-content/uploads/rating-the-states-midterm-2013_IBHS.pdf
- Insurance Institute for Business & Home Safety. (n.d.). *Land use*. Retrieved May 4, 2014, from <https://www.disastersafety.org/land-use/>
- International Council of Scientific Unions, Scientific Committee on Problems of the Environment. (1980). *Environmental risk assessment: Scope 15*. Retrieved from http://dgc.stanford.edu/SCOPE/SCOPE_15/SCOPE_15.html
- Intergovernmental Panel on Climate Change. (2012). *Managing the risks of extreme events and disasters to advance climate change adaption*. Retrieved from https://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf
- Intergovernmental Panel on Climate Change. (2013). *Climate change 2013: The physical science basis*. Retrieved from http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf
- Israel, N.D. (2013, October) *Inaction on climate change: The cost to taxpayers*. Retrieved from Ceres website: <http://www.ceres.org/resources/reports/inaction-on-climate-change-the-cost-to-taxpayers/view>
- JPMorgan Chase. (n.d.). *Expanding bond market for green projects*. Retrieved April 30, 2014, from <http://www.jpmorganchase.com/corporate-responsibility/green-bonds>
- Koba, M. (2014, February 7). *Flood insurance battle reaching high-water mark*. *CNBC News*. Retrieved from <http://www.cnn.com/id/101396047>
- Koba, M. (2014, February 7). *Flood insurance battle reaching high-water mark*. *CNBC News*. Retrieved from <http://www.cnn.com/id/101396047>
- Kousky, C. (2011). Managing Natural Catastrophe Risk: State Insurance Programs in the United States. *Review Of Environmental Economics & Policy*, 5(1), 153-171. doi:10.1093/reep/req020

- Leurig, S. & Dlugolecki, A. (2013, March). *Insurer climate risk disclosure survey: 2012 findings & recommendations*. Retrieved March 12, 2014, from Ceres website: <http://www.ceres.org/resources/reports/naic-report/>
- Luke, C. & Abramovsky, A. (2011). Managing the Next Deluge: A Tax System Approach to Flood Insurance. *Connecticut Insurance Law Journal*, 181.
- Lloyds. (2011). *Managing the escalating risks of natural catastrophes in the United States*. Retrieved from <http://www.lloyds.com/~media/lloyds/reports/emerging%20risk%20reports/natural%20catastrophes%20in%20the%20us.pdf>
- Maddux, J.E. & Rogers, R.W. (1983). Protection motivation and self-efficacy: A revised theory of fear appeals and attitude change. *Journal Of Experimental Social Psychology*, 19,469-479. doi:10.1016/0022-1031(83)90023-9
- MarketLine. (2013, October) *Global reinsurance [Industry overview]*. Retrieved from http://content.ebscohost.com/pdf29_30/pdf/2013/Y3K/01Oct13/91862731.pdf?T=P&P=AN&K=91862731&S=R&D=bth&EbscoContent=dGJyMNHX8kSep7M4xNvgOLCmr0yep7VSsKe4S7CWxWXS&ContentCustomer=dGJyMPGptkm2rbBJuePfgeyx43zx
- McHale, C. & Leurig, S. (2012, September). *Stormy future for U.S. property/casualty insurers: The growing costs and risks of extreme weather events*. (Research Report) Retrieved from Ceres website: <http://www.ceres.org/resources/reports/stormy-future/view>
- Megosh, A., Scollich, L., Salins, M.J., Chasin, C. (2001). Private benefit under IRC 501(c)(3). In *Internal revenue service continuing professional education text for fiscal 2001*. [Adobe Digital Editions version]. Retrieved from <http://www.irs.gov/pub/irs-tege/eotopich01.pdf>
- Mills, E. (2005). Insurance in a climate of change. *Science* 309(1040). doi: 10.1126/science.1112121
- Mills, E. (2007). Synergisms between climate change mitigation and adaptation: An insurance perspective. *Mitigation And Adaptation Strategies For Global Change*, (5), 809. doi: 10.1007/s11027-007-9101-x
- Mills, E. (2009). A Global Review of Insurance Industry Responses to Climate Change. *Geneva Papers On Risk & Insurance - Issues & Practice*, 34(3), 323-359. doi:10.1057/gpp.2009.14
- Mills, E. (2012). The greening of insurance. *Science*, 338(6113), 1424-1425. doi:10.1126/science.1229351
- Mills, E., & Lecomte, E. (2006, August). *From risk to opportunity: How insurers can*

- proactively and profitably manage climate change*. Retrieved from <http://www.ceres.org/resources/reports/how-insurers-can--manage-climate-change-2006>
- Mills, E., Roth R.J., & Lecomte, E. (2006). Availability and affordability of insurance under climate change: A growing challenge for the U.S. *Journal of Insurance Regulation*, 25 2, pp. 109-149.
- Munich Re. (2010). *A basic guide to facultative and treaty reinsurance*. Retrieved from http://www.munichreamerica.com/site/mram/get/documents_E96160999/mram/assetpool_mr_america/PDFs/3_Publications/reinsurance_basic_guide.pdf
- Munich Re. (2011) *NatCatSERVICE: Natural catastrophe know-how for risk management and research*. Retrieved from http://www.munichre.com/site/corporate/get/documents_E1618493477/mr/assetpool.shared/Documents/0_Corporate%20Website/_Publications/302-06733_en.pdf
- MunichRe. (2012, June 8). Geointelligence opens up new possibilities. *Topics Online*. Retrieved from <http://www.munichre.com/en/reinsurance/magazine/topics-online/2012/04/nathan/index.html>
- Munich Re. (n.d.) *Munich Re TOUCH—The information portal*. Retrieved on March 28, 2014, from <https://www.munichre.com/touch/portal/en/homepage/default-naturalhazards/index.html>
- Papenfuzz, A.L. (1964). Reinsurance from the buyer's standpoint. In America Management Association Bulletin 39, *Reinsurance: methods, markets, and economies* (pp. 13-17). New York, NY.
- Plambeck, E., & Denend, L. (2011). The greening of Walmart's supply chain...revisited. *Supply Chain Management Review*, (5). 16.
- Reichelt, H. (2010). Green bonds: a model to mobilise private capital to fund climate change mitigation and adaptation projects. In *The euromoney environmental finance handbook 2010*. Retrieved from http://treasury.worldbank.org/web/Euromoney_2010_Handbook_Environmental_Finance.pdf
- Reinsurance Association of America. (2007). *Fundamentals of property and casualty reinsurance with a glossary of reinsurance terms*. Retrieved on March 2, 2014 from, <http://www.reinsurance.org>
- Reinsurance Association of America. (2008). *Climate change policy*. Retrieved from <http://www.reinsurance.org>
- Risky Business. (n.d.). *About the project*. Retrieved on May 1, 2014 from, <http://riskybusiness.org/about>

- Risk Management Solutions. (2012). *CAT bonds demystified: RMS guide to the asset class*. Retrieved from https://support.rms.com/publications/cat_bonds_demystified.pdf
- Rogers, C. (2005). *Financial reporting of environmental liabilities and risks after Sarbanes-Oxley*. Hoboken, NJ.
- Saltuk, Y., Bouri, A., & Leung, G. (2011, December 14). *Insight into the impact investment market: an in-depth analysis of investor perspectives and over 2,200 transactions*. Retrieved from the Global Impact Investing Network website: <http://www.thegiin.org/cgi-bin/iowa/resources/research/334.html>
- Semenova, N., & Hassel, L. G. (2008). Financial outcomes of environmental risk and opportunity for US companies. *Sustainable Development*, 16(3), 195-212. doi:10.1002/sd.365
- Smith, B. D., & Wining, E. A. (1994). *How insurance works*. Malvern, PA: Insurance Institute of America.
- Smith, J. (1964). The financial effect of reinsurance. In America Management Association Bulletin 39, *Reinsurance: methods, markets, and economies* (pp. 3-9). New York, NY: American Management Association.
- Swiss Re. (2009, October). *Disaster risk financing: A paradigm shift*. Retrieved on April 19, 2014, from http://www.swissre.com/reinsurance/insurers/property_specialty/disaster_risk_financing_a_paradigm_shift.html
- Swiss Re. (2010, June) Microinsurance—Risk protection for 4 billion people. *Sigma online*. Retrieved from http://media.swissre.com/documents/sigma6_2010_en.pdf
- Swiss Re. (2011). *Closing the financial gap: New partnerships between the public and private sectors to finance disaster risks*. Retrieved February 5, 2014, from http://media.swissre.com/documents/pub_closing_the_financial_gap_W1.pdf
- Swiss Re (2013a). Natural catastrophes and man-made disasters in 2012: A year of extreme weather events in the US. *Sigma Online*, 2. Retrieved from http://www.eenews.net/assets/2013/03/28/document_cw_01.pdf
- Swiss Re. (2013b). *Natural hazards at a glance: CatNet the online natural hazard atlas*. Retrieved from http://media.swissre.com/documents/NatCat_Naturgefahren_auf_einen_Blick_en.pdf
- Swiss Re. (2013c). *The essential guide to reinsurance*. Retrieved March 8, 2013, from http://media.swissre.com/documents/The_essential_guide_to_reinsurance_updated_2013.pdf

- Swiss Re. (n.d.) *CatNet*. Retrieved March 20, 2014, from http://www.swissre.com/clients/client_tools/about_catnet.html
- Thistlethwaite, J. (2012). The ClimateWise Principles: Self-Regulating Climate Change Risks in the Insurance Sector. *Business & Society*, 51(1), 121. doi:10.1177/0007650311427595
- Torregrosa, D. (2002). *Federal reinsurance for disasters [electronic resource]*. [Washington, D.C.] : Congress of the U.S., Congressional Budget Office.
- The United Nations Office for Disaster Risk Reduction. (2013). *Global assessment report on disaster risk reduction*. Retrieved from <http://www.unisdr.org/we/inform/publications/33013>
- U.S. Department of Commerce, National Oceanic and Atmospheric Administration. (2013, May). *Service assessment: Hurricane/post-tropical cyclone Sandy October 22-29, 2012*. Retrieved from <http://www.nws.noaa.gov/os/assessments/pdfs/Sandy13.pdf>
- U.S. Department of Energy. (n.d.). *Residential renewable energy tax credit*. Retrieved from <http://energy.gov/savings/residential-renewable-energy-tax-credit>
- U.S. Environmental Protection Agency. (n.d). *Natural infrastructure and green communities: Linking landscapes and communities*. Retrieved March 28, 2014, from http://www.epa.gov/greenkit/natural_infrastructure.htm
- Urban Land Institute. (2013). *Risk & resilience in coastal regions*. Retrieved from <http://www.uli.org/wp-content/uploads/ULI-Documents/CoastalRegions.pdf>
- Warner, K. et al. (2009). *Adaptation to climate change: Linking disaster risk reduction and insurance*. Retrieved from the United Nations Office for Disaster Risk Reduction website: <http://www.unisdr.org/we/inform/publications/9654>
- World Bank Treasury. (n.d.) *World bank green bonds*. Retrieved April 30, 2014 from <http://treasury.worldbank.org/cmd/htm/WorldBankGreenBonds.html>
- World Wildlife Fund & The Coca-Cola Company. (2013, July). *2012 Annual review: WWF/Coca-Cola partnership*. Retrieved February 19, 2014, from http://assets.worldwildlife.org/publications/601/files/original/110713_Coca_Cola_Annual_Review_Web.pdf?1373925746
- World Risk and Insurance News. (Producer). (2014, February). *New Oasis loss modeling framework promises transparency and cost reduction [Interview with Trevor Maynard]*. Retrieved from <http://wrin.tv/index.php/component/content/article/3-headline/1126-oasis-a-new-loss-modeling-framework>

Zurich. (2013, November 18). *Zurich invests up to USD 1 billion to help communities adapt to climate change*. Retrieved from <http://www.zurich.com/media/newsreleases/2013/2013-1118-01.htm>